Research Article

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Development of Lift-off Process Using Plasma Enhanced Chemical Vapour Deposition Silicon Dioxide

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ABSTRACT

Lift-off[1] is a simple, easy method for realizing metal patterns on a substrate, especially for thin metal films such as platinum, gold, and titanium, difficult to be etched by conventional methods. Defining metal lines at sizes below 2µm is difficult by wet and plasma chemistry. We have carried out lift-off process experiments using positive photoresist Fuji Film OiR 906-17HD, PECVD silicon dioxide of 1µm, and metal thickness of 1000µm, 1500 µm, and 2000 µm on silicon and quartz wafers. Different dimensions of metal patterns were achieved with 3% accuracy on silicon and quartz wafers. This method can be used for the realization of various MEMS[2] devices.

Keywords: Lift-off, Photoresist; Micromechanical systems (MEMS); Plasma enhanced chemical vapor deposited (PECVD).

1. INTRODUCTION

Lift-off[1] is a technique for patterning metal lines on a substrate like silicon and quartz wafers. Most of the noble metals are used as connectors in MEMS[2] devices such as accelerometer, pressure sensor, and temperature sensor in the current scenario. Metals like gold, chromium, and titanium which are difficult to be etched by wet chemical and plasma chemical methods. The general Lift-off process includes desirable patterning with photoresist, and metal lines are deposited on photoresist pattern. During the actual lifting-off, the photoresist under the film is removed with a clean solvent process, taking the film with it and leaving only the film or metal deposited directly on the substrate. Defining Nano level metal lines at sizes below 2µm is difficult by wet etching or plasma to etch method. The lift-off process is an economical and alternate method to avoid wet chemicals and plasma gasses damaging the device metal lines (Shilpi *et al.* 2016). In this study, we developed a process using positive photoresist Fuji Film OiR 906-17HD, silicon dioxide of 1µm, the metal thickness of 1000 °C, 1500 °C, and 2000 °C on silicon and quartz wafers.

2. MATERIALS & METHODOLOGY

The following process sequence illustrates the PR lift process using a positive tone photoresist and sacrificial silicon dioxide (SiO_2) as assisting layer. A thick layer of SiO_2 (the thickness of SiO_2 should be greater than that of the thin-film device material ~1µm) was first deposited, followed by a spin-coat of photoresist (OiR 906-17HD, ~3µm). The mask pattern was defined into the photoresist layer. By using the patterned photoresist as the etch mask, the SiO_2 layer was wet chemically etched. In order to create an overhang structure with the photoresist, the SiO_2 layer was intentionally over-etched Fig. 1. Lift-off was done by dissolving the photoresist in acetone in an Ultrasonic bath.

2.1 Liftoff on Silicon Wafer

1µm PECVD oxide was deposited on fresh Si wafers, followed by photolithography and removal of 1µm PECVD oxide by buffer oxide solution for undercut profile and subsequent metal deposition and photoresist lift-off was done. Metals like chromium, titanium, and sandwich of titanium & platinum were used in the experiments. Photomask patterns with dimensions of 5µm, 10µmand 50µm were used in the experiment.

2.2 Liftoff on Quartz Wafer

Stack of 1520 °C LPCVD silicon nitride& 1µmPECVD oxide was deposited on quartz wafers, which was followed by photolithography and removal of 1µm PECVD oxide by buffer oxide solution for undercut profile and subsequent metal deposition and photoresist lift-off was done Metals like chromium, titanium, and sandwich of titanium & platinum were used in the experiments. Photomask patterns with dimensions of 5µm, 10µmand 50µm were used in the experiment.

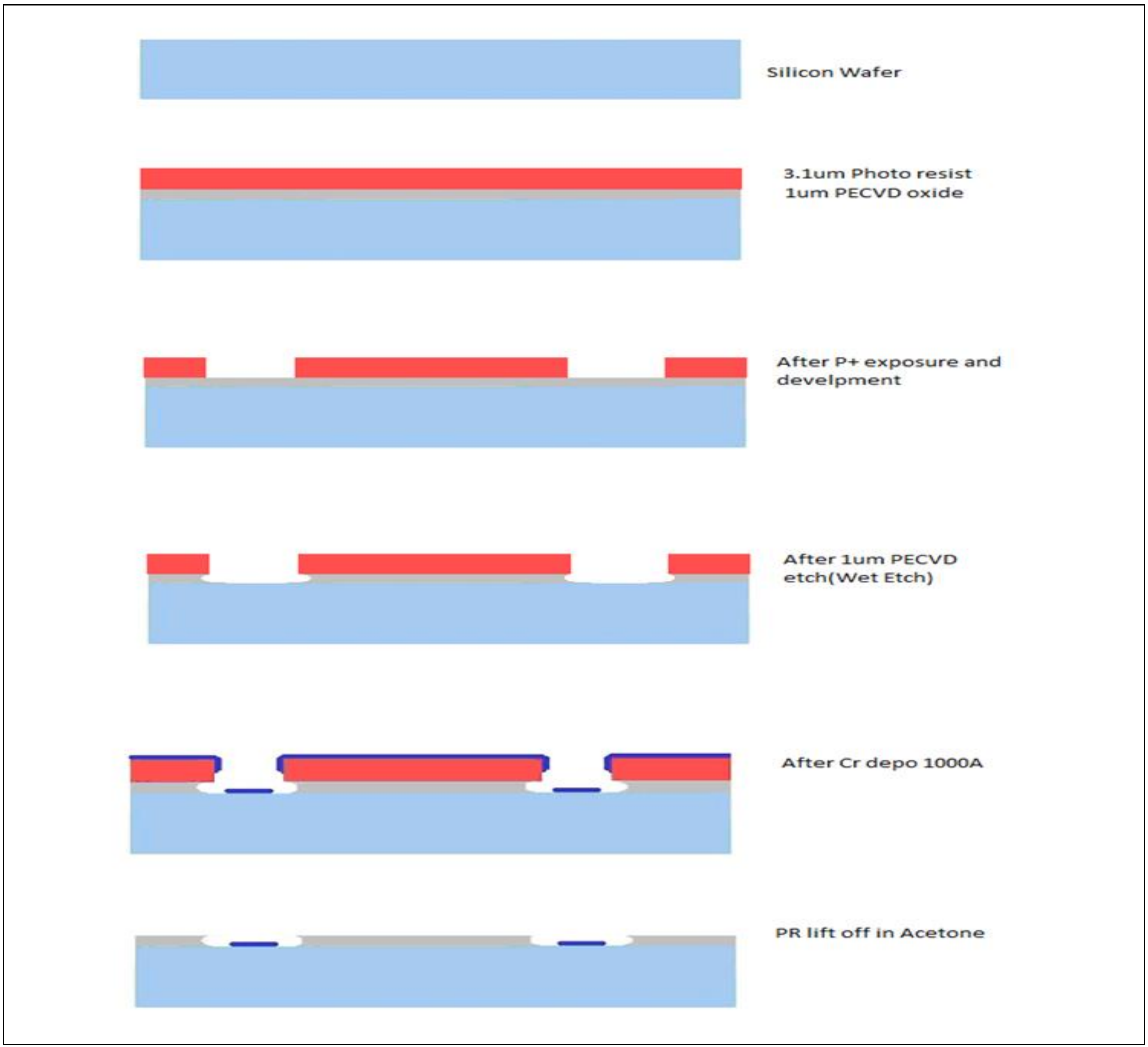

Fig. 1: Processing Steps of the Lift-off Method Based on the Photoresistor Oxide Double Layer Scheme

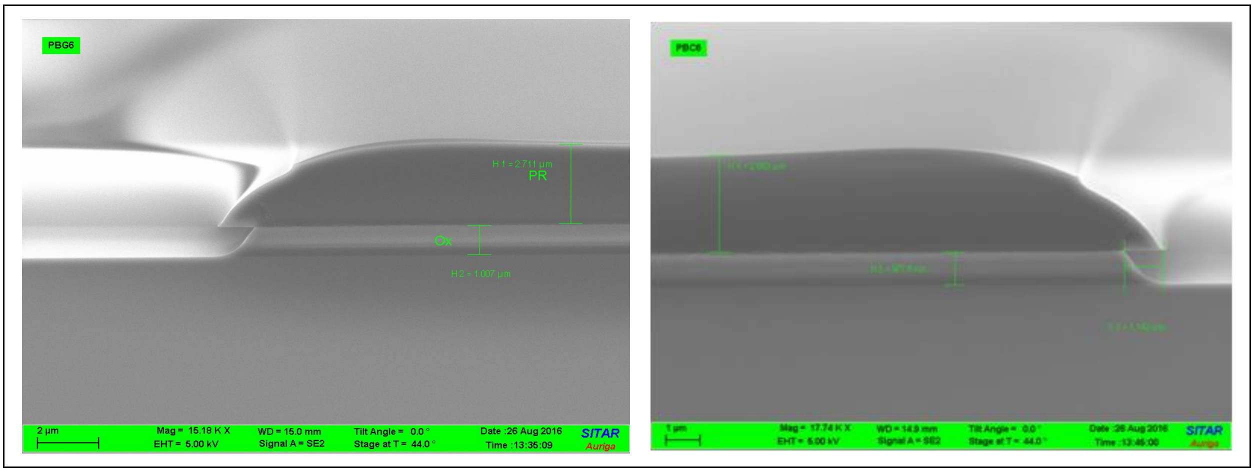

Fig. 2: Scanning Electron Microscopy (SEM) Image After SiO2 Etch

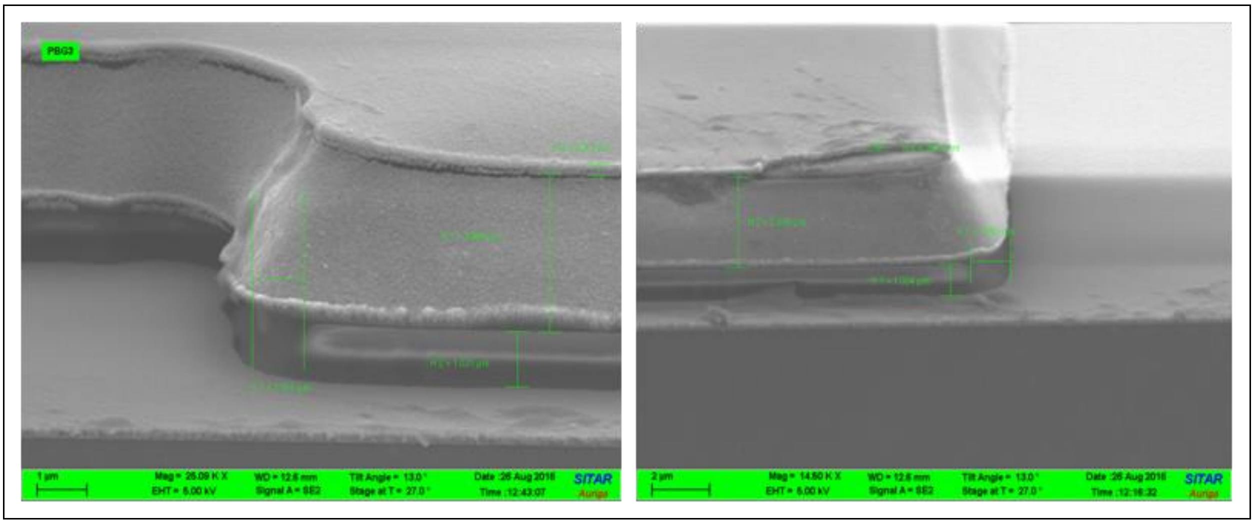

Fig. 3: SEM Pictures after 1000° Chromium and Titanium Deposition

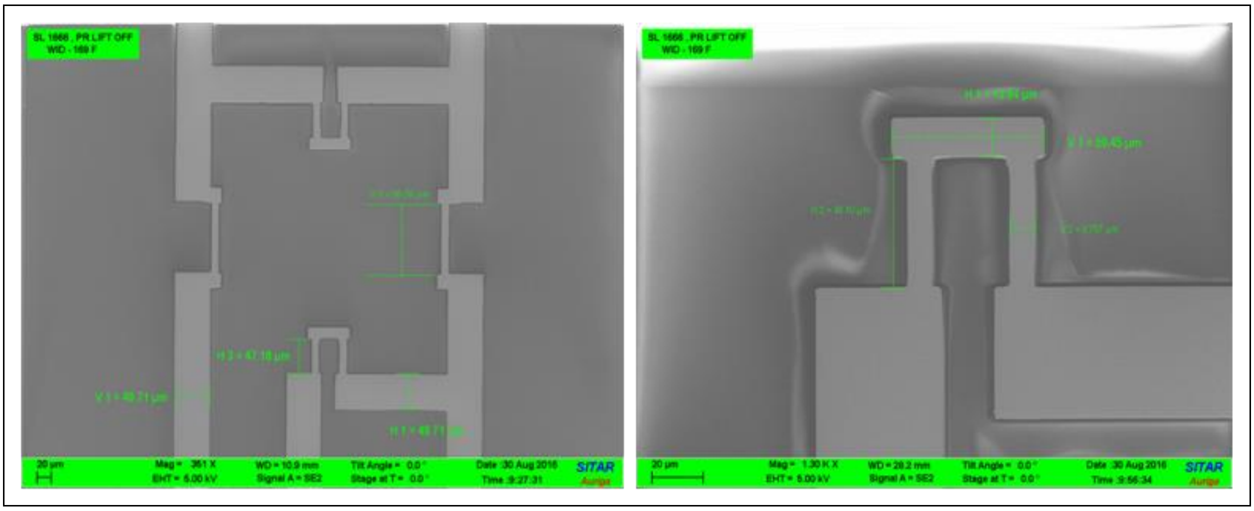

Fig. 4: SEM Image of Metal after Lift-off Process on Si Wafer

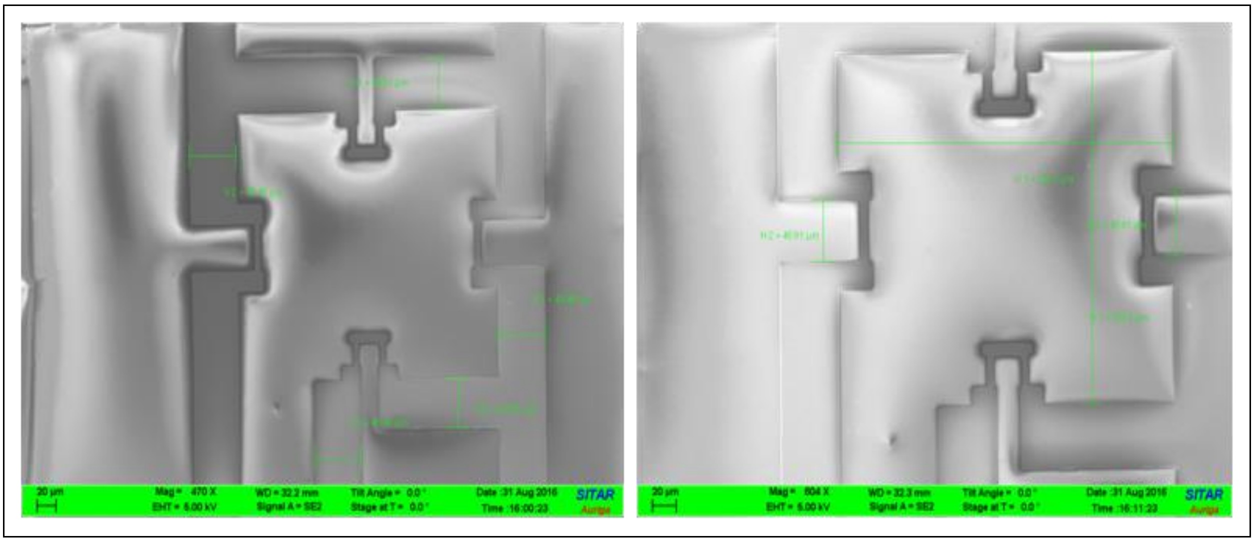

Fig. 5: SEM Image of Metal after Lift-off Process on a Quartz Wafer

3. CONCLUSION

All the experiments were carried out successfully for both Si and Quartz wafer with different metal thicknesses and PECVD SiO_2 as an assisting layer. All the metal line dimensions were achieved with 3% tolerance. This investigation studies showed an economical and easy lift-off process using PECVD SiO_2asan assisting layer, and it can be used in various MEMS device fabrication to avoid wet chemicals.

4. ACKNOWLEDGEMENT

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REFERENCES

Shilpi Pandey, Deepak Bansal, Deepak Panwar, Neha Shukla, Arvind Kumar, Prateek Kothari and Seema Verma, Low Cost Lift-off Process Optimization for MEMS Applications AIP Conference Proceedings 1724, 020105 (2016). https://doi.org/10.1063/1.4945225